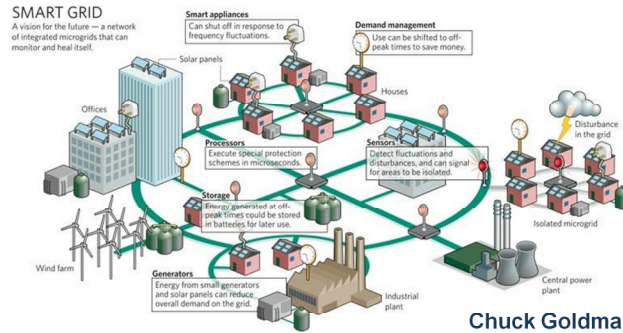


An Introduction - Smart Grid 101

Chapter 7: Customer Automation Technology



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Lawrence Berkeley National Laboratory - Smart Grid Technical Advisory Project

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The Smart Grid is a compilation of concepts, technologies, and operating practices intended to bring the electric grid into the 21st century. Smart Grid concepts and issues are difficult to address because they include every aspect of electric generation, distribution, and use.

While the scope of smart grid covers the entire utility system from generation to how customers use energy, this chapter addresses the topic of demand response.

Our objective throughout this chapter is to more clearly define demand response, to point out policy, technology, and customer behavior combine to define the capabilities and potential benefits of Smart Grid.

Webinar Objectives

- ❑ Highlight the status of smart appliance and device development activities for Smart Grid
- ❑ Address regulatory issues that impact security and privacy, cost, standards, interoperability, and implementation options.



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Two objectives were established for this webinar.

1. We want to highlight the developmental status of smart appliances and other devices that support customer automation consistent with the smart grid vision.
2. We also want to address many of the regulatory issues that impact smart grid implementation, specifically security and privacy, interoperability, standards, and cost implications.

One of the practical limitations of smart grid is the expectation that consumers will modify their energy usage behavior to become more efficient, reduce or shift peak load, and participate in other options to better integrate supply and demand. Numerous load management and pricing pilots over the last 30 years have shown that customers are willing and capable of supporting these smart grid objectives, however that willingness is substantially facilitated and to some degree dependent upon appliances with integrated control systems and other control technologies that allow the customer to automate their operating and behavior preferences. We use the term later in this presentation, however “set and forget it” is a perfect way to describe what consumers want.

This webinar can only sample a small fraction of the product and system development efforts underway with appliance manufacturers and consumer electronic companies. While we’ve listed several references in this presentation to highlight a few vendors, our research has identified almost 100 companies innovating new products and services to address consumer smart grid needs. Links to online videos and approximately 50-60 vendors is provided in the reference slides at the end of this chapter. Technology is not the problem.

Webinar Agenda

1. Setting the stage
2. Available Technologies
3. Regulatory Issues
4. Summary
5. References



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This webinar is divided into five segments as outline above.

1. Setting the Stage



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Customer automation technology is one of the most interesting and exciting areas of smart grid activity. The technology itself is interesting because it combines innovation, Internet, and interesting applications to address energy efficiency, demand response, and other functions usually reserved for electric utilities. Automation technology is also interesting because it impacts the future design, features, and operation of many of the appliances and other devices we actually use every day.

The environment for customer automation technology is also interesting because it challenges the basic business model of the regulated utility and poses an even more interesting dilemma for regulators. For customer automation technology and smart appliances to succeed will require opening the door to what is now an exclusive set of utility efficiency and demand response programs to outside participation. To a very significant degree, the market for smart appliances and low-cost sophisticated controls will also require more widespread applications of dynamic pricing. Dynamic pricing is critical for establishing the customer value function, which is essential to support product development and distribution.

While Utilities can provide customers with an air conditioner control switch, they cannot provide customers with the diversified range of appliances and electronic devices that populate their premises and business which have capability and are necessary to provide smart grid benefits. While manufacturers and entrepreneurs are already announcing very innovative new products and services to support smart grid, we don't think they will be offered broadly until customers have a financial incentive to purchase these products.

Why Should Regulators be Interested ?

Customer Automation Technology

- ☐ Improves the magnitude and persistence of customer response
- ☐ Is necessary to support the dispatch of day-ahead and day-of demand response
- ☐ Is necessary to support the integration of electric vehicles, local renewables, and Smart Grid operations
- ☐ Provides consumers with “set it and forget it” energy management capability.



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Why should regulators be interested in customer automation technology?

We've identified four major reasons why customer automation technology is important and how essential it will be in development of smart grid.

1. What we've learned from the pricing and demand response pilot programs over the last 25-30 years is that automation technology improves the persistence and magnitude of customer response. Customers that just receive some type of notification of either a price or event, don't respond as well as those with utility controlled equipment like that used in direct control pilots. Many of the pilots in the last ten years have shown that customers respond even better when they control their own appliances and loads and determine their own control strategies.
2. Demand response for smart grid will require electronic links to support reliable, fast response. Automation of customer response is essential to support day-of, fast response applications.
3. Automation will also be required to integrate and manage electric vehicles, other onsite renewables, and other aspects of smart grid operations.
4. Automation provides customers with the tools to establish their response to prices and events and then walk away until conditions require a change in strategy. The ability to “set it and forget it” is essential to support a consistent and reliable customer response.

Frequently Asked Questions

- | | |
|--|---------|
| 1. Are customer automation technologies (products and services) available today? | Yes |
| 2. Are there options to address interoperability and future proofing? | Yes |
| 3. Can implementation proceed before the NIST standards have been completed? | Yes |
| 4. Can security and privacy be addressed? | Yes |
| 5. Is there a viable market for customer automation technologies | Not Yet |



When we put together this presentation we tried to structure the material to answer five basic questions relevant to smart grid regulatory issues. We also provided, in advance, the answers to each of these questions, which are supported by the material that follows.

2. Available Technologies*

Technology is not the problem.

* Available technologies are provided as examples not as endorsements for any individual product or service.



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We start this presentation with examples of Customer Automation Technology . Providing actual examples of different devices, controllers, and different systems is the best way to demonstrate that technology is not the problem, to illustrate the potential, and to then examine the issue that either hinder or facilitate their commercialization and deployment of customer automation technology..

What is Available ?

- ☐ **Communicating Thermostats**
- ☐ **Smart Appliances**
- ☐ **Plug-load devices**
- ☐ **In-home Displays**
- ☐ **Energy Management Systems / Services**



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We've chosen to highlight a spectrum of products divided into categories that enable energy savings and demand response through operational attributes. The product categories shown above are in increasing order of "system complexity". Programmable thermostats are part of a standalone HVAC system but when you add communications and make them programmable communicating thermostats (PCTs), they become part of a much more complex system. PCTs are probably the least expensive, most widely tested, and easiest device to use to provide smart grid capability.

Communicating Thermostats -1

Honeywell UtilityPro PCT



- Utility cost estimated \$200 wholesale
- Primary Market: Utility programs
- ZigBee enabled
- Designed for utility demand response functions
- Web programmable

Ecobee Smart Thermostat



- Approximate Cost \$470 retail
- Utility cost estimated \$200 wholesale
- Primary Market: Retail
- WiFi and ZigBee enabled
- Touch screen
- Remote sensors available
- Price response capability
- iPhone / Web aps provided



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Programmable Communicating Thermostats (known as PCTs) have been around since the late 1990's when Carrier Corporation developed a prototype that used a private 2-way pager communications channel to send setpoint signals (commands) to air-conditioning units. Setpoint signals common to utility demand response programs are technically proxies for price, reliability and event signals. Tens of thousands of Carrier PCTs were successfully installed across the country – most notably at SDG&E, SCE, and LILCO.

In retrospect, the Carrier PCTs had 2 deficiencies: (1) they were essentially prototypes designed for low-volume utility pilots and therefore, costly to make and install, and (2) Carrier choose a communications channel (paging) that was about to rapidly decline in popularity over the next 5 years making it more costly to operate as time went on.

In the past 10 years, many companies (Cannon working with Honeywell, Comverge working with White-Rodgers, Corporate Systems, etc.) have produced PCTs in relatively low volumes (on the order of 100,000s) exclusively for utility programs. These PCTs have remained expensive to manufacture and install generally because different utilities may require customized functions or use different communications channels. Wholesale prices in volumes of 100,000 are typically above \$200 per unit before the costs of installation, communications support, or maintenance.

This slide displays 2 of the more recent PCTs that have been brought to market, including the Honeywell UtilityPRO PCT and the Ecobee Smart thermostat. At the time this chapter was drafted the prices were still in the \$200 or higher range. Both PCT's support different communications channels. The version of Zigbee (SEP 1.0) included in both PCT models is not the version (SEP 2.0) under consideration by NIST.

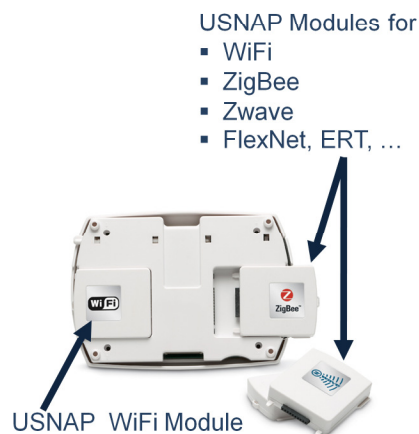
There are currently 4 generations of ZigBee-enabled devices that are not backward compatible and will not be compatible with the version SEP 2.0 version currently being developed.

Communicating Thermostats -2

3M Filtrete Smart Thermostat



- Approximate Cost \$99.95 Retail
- Primary Market: Retail
- WiFi enabled
- USnap Modules (2) capable
- Grid status indicators
- Price response capability
- iPhone / Web aps provided
- Multiple product options to > \$200



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About 5 years ago the California Energy Commission Public Interest Energy Research (PIER) program funded research to create a reference design for PCT technology. The research sought to develop a more standardized design that could result in a much less expensive PCT product (the goal was less than \$100 retail). The research objective was to produce a public specification with more universal functionality that could be made available to any manufacturer. The research approach borrowed concepts from the PC industry, namely the use of expansion ports and slots that would allow PCTs to have capability to adapt to and outlive (not be stranded by) ever-changing communications technologies.

The CEC PIER PCT technology reference design was successfully completed around 2008. One of the first manufacturers to use the design started releasing their first commercially available retail products at Home Depot under the 3M Filtrete label in December 2010. The graphics on this slide depict the 3M Filtrete product. It is instructive to compare and contrast the latest utility-specified PCTs with this retail PCT.

The 3M Filtrete PCT includes 2 USNAP expansion ports (illustrated above), each of which can accept a variety of plug-in modules that support current and future communications options including ZigBee, Wi-Fi, Z-wave, OpenADR, etc. The initial Home Depot package, at a retail price of \$99.95, includes a Wi-Fi insert and iPhone application. The two expansion ports make it possible for the PCT to support different “to-the-home” and “within-the-home” communications channels. For example, to the home could be Wi-Fi through a standard home router and within the home could be Z-wave.

Communicating Thermostats - 3

3M Filtrete Smart Thermostat

Home Depot
Retail Blister Pack



Sample iPhone / Web Screens



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This slide provides a snapshot of the 3M Filtrete computer and iPhone information screens. These web based interfaces allow the customer to program and otherwise manage their thermostat functions remotely in addition to traditional programming on the thermostat itself.

The computer and iPhone applications are included with the hardware at no additional cost.

Smart Appliances - 1



Embedded Demand Response Strategies

- Delay operation, defrost cycle
- Modify peak run time
- Reduced Peak features
- Low Power mode
- Temperature shift
- Listen for price / event signals



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GE, LG, Whirlpool and other appliance manufacturers have recently announced “smart” (meaning communicating) appliances. The GE products are based on their present top-of-the-line appliances because these products already contain some of the electronics needed to be smart, e.g., they already include a microprocessor, memory, displays, software applications, and sensors. To make them into smart appliances, GE and other vendors only need to add a 2-way transceiver to allow communications to take place between the appliance, the utility or customer service provider, and other sources of information. They have already begun to add new software that is consistent with Smart Grid operations that support demand response.

The question GE (and their competitors) are still struggling with is “which communications transceiver should they use?” This is a place where regulators can help – NOT by choosing a particular communications transceiver (i.e., ZigBee, Wi-Fi, etc.) but by insisting that the products be future proofed by employing a USNAP or other standardized expansion port or slot. GE has considered the USNAP port used in the 3M product and probably has looked at other options such as USB (which is presently used in computers), SDIO (which is used in cameras), etc. They and their competitors will eventually figure out what’s best for their industry. The only bad choice would be not to have future proofing. Having an expansion port, for example, doesn’t eliminate offering a fixed transceiver. It just guarantees that if the fixed transceiver does not become the industry standard, there will be a simple way for consumers to upgrade (that means override) the hardware transceiver with whatever now is considered the best communications option.

It’s important to also understand that communications to the home may be different than communications within the home. GE is currently promoting a gateway device called “Nucleus” that provides two generic functions: (1) it can convert messages from an external to-the-home communications channel to messages on an in-the-home communications channel, and (2) it serve as a residential Energy Management Control System (EMCS).

Plug Load Devices

thinkeco modlet

- Automatically turns off if not in use *
- Being developed to remotely control window AC, other loads **



Enmetric Power Port

- Wireless communication
- Demand Response capable
- Analytics and reporting

* <http://www.triplepundit.com/2010/10/thinkeco-modlet-makes-easy-save-energy/>
** http://thinkecoinc.com/data/ThinkEco_ConEd_2011_01_05.pdf



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Companies such as Enmetric are building self-contained plug-load subsystems that use a fixed communications network. In order to be compatible with other subsystems, they provide a bridge (gateway) module (similar to the GE Nucleus gateway module) to exchange information with other in-home communications networks.

In Home Displays

- ❑ Separate physical devices
- ❑ Additional investment and implementation cost
- ❑ Functionality available in computer, phone, and integrated devices
- ❑ Studies indicate that separate devices have limited market / value.



Source: List of Energy Monitoring Tools, Devices, Software and Home Automation,
<http://blog.mapawatt.com/2009/10/07/list-of-energy-monitoring-tools/>



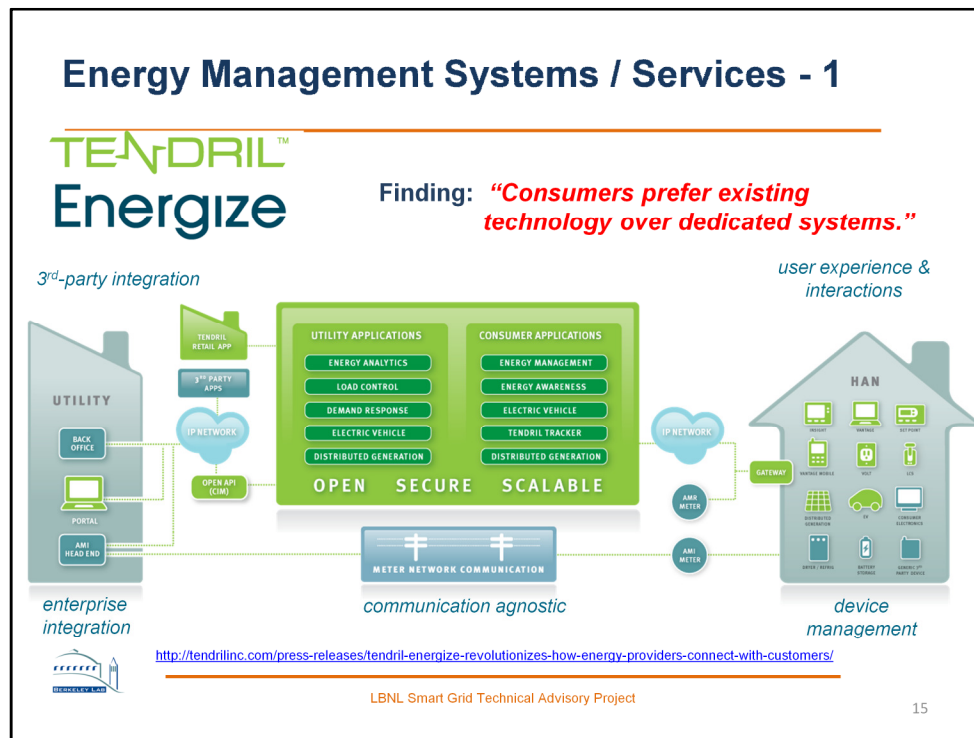
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Utilities have been promoting energy-focused, In-Home Display (IHD) modules using ZigBee communications. Separate hardware based IHDs may not be a good economic choice because consumers increasing own display devices like smart phones, tablets, computers, TV monitors, and thermostats with displays that already have all the necessary hardware to be an IHD. For example, the 3M Filtrete thermostat described earlier, has a display and an applications for a PC and the iPhone that could easily provide everything a separate stand alone IHD provides for no additional hardware cost to either the consumer or utility. Software based IHDs are also easier to update and integrate with new applications.

Wholesale prices for stand alone utility IHDs are expected to be in the range of \$50-\$200. Using an existing display that the consumer already owns and knows how to operate is not only much less expensive but requires no new paradigm to learn to use.

Recent research projects are also showing that consumers prefer displays either embedded in an existing appliance or accessible from an existing device. Separate, stand along display devices are considered unnecessary.



One of the most interesting innovations coming to consumers may be low- or no-cost energy management control systems (EMCS) and energy management system (EMS) services. This slide illustrates Tendril’s system architecture based on devices consumers already own.

Notice the quote in red in the upper right hand corner.

Also notice that Tendril has separated their EMCS (the green block) from the utility network. Their EMCS exists in the Internet cloud, not in hardware at the customer site. Similar architecture already exists in the EMCS and EMS used in large commercial and industrial establishments. In fact, affordable EMCS for residential facilities is possible and being explored by many vendors as an alternative and to avoid dependence on a utility offering. Some of these company offerings are being structured as collaborations with home security system providers, home entertainment systems, and home network information technology companies such as Cisco Linksys, etc. The consumer electronics industry has a much broader vision of systems for the home that includes the integration of medical, energy, entertainment, security, and other services that can be part of an existing home network. The consumer electronics industry already makes extensive use of the Internet cloud to continuously upgrade and future-proof their products.

The rapid growth and interest of consumer electronic companies in smart grid is illustrated by the annual Consumer Electronic Show (CES). For the last two years, the CES has featured a separate section to highlight smart grid consumer electronics.

Energy Management Systems / Services - 2



Smart Thermostat



- Cost: Thermostat neutral
- Primary Market: Consumer
- WiFi enabled
- Comfort optimization
- iPhone / Web apps provided

ECOFACOR-ENABLED THERMOSTAT & SERVICE	PROGRAMMABLE THERMOSTAT
Manually adjust temperature on thermostat	✓
Time of day programming	✓
Day of week programming	✓
Average annual savings	Up to \$400
Average optimization adjustments per day	20-30
Automatically adjusts settings based on expected weather	✗
Remote access via the internet	✗
Monitor your energy and cost savings	✗

Oncor Program:

- \$19.95 one time installation
- \$8.99 / month monitoring fee



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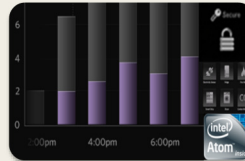
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EcoFactor is another innovator and service provider that entered the residential energy management space around 2007. EcoFactor won the 2009 National CleanTech award by creating a consumer focused service that can also work independently or with utility programs (e.g., the Oncor Program in Texas). EcoFactor utilizes a Wi-Fi enabled thermostat to connect the home to the Internet cloud where EcoFactor servers continuously monitor and “learn” customer comfort preferences. Customer thermostat setting are used to perform customized analytics (model computations) to save energy, reduce demand, and maintain comfort. In the cloud, EcoFactor has access to local weather, up-to-date news about the grid, etc., that can be used to optimize customer preferences for comfort, energy savings and life-style choices.

EcoFactor and several other vendor systems are being designed to manage daily energy use as well as provide peak load reduction and other demand response capability.

Energy Management Systems / Services - 3

Intel® Home Dashboard - Reference Design Kit



Rich Consumer Experience

- Simple home management
- Personalized Recommendations
- Significant energy savings
- Accurate budgeting
- Set goals, earn rewards, share results

Clear Utility Benefits

- Integrate with utility smart energy systems
- Enable demand response savings
- Leverage existing smart grid and meter investments
- Drive customer loyalty

Open, Extensible Platform

- Integrate via open standards with 3rd party products and services like thermostats, security, home appliances, etc.
- Extend via open APIs with application store and 3rd party apps



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Intel is developing a “Reference Design Kit” for Home Energy Management Systems (HEMS) that will (1) facilitate the use of existing standards, and (2) leverage existing communications infrastructures. Intel believes that energy management is just another application that can be facilitated by Internet Protocol (IP) standards and can be implemented on existing IP devices already owned by consumers.

A Lawrence Berkeley National Laboratory project called REDS (Residential Energy Display Survey) is attempting to show that utility-defined IHDs (in-Home Displays) may be unnecessary since existing smart phones, PCs, TVs, PCTs, X-Boxes, etc., already have much better displays, software, communications, etc., than the proposed single-purpose IHDs. Later this summer, this Smart Grid Technical Advisory Project will offer another Webinar and another chapter on “Customer Data Access” that will include results from and more information about the REDS project.

The main message from these past few slides is that “technology is not a problem”. Cost effective products can be created.

3. Regulatory Issues

Are there regulatory policies and actions that impact the potential success or failure of consumer automation technologies and services?



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New technology opportunities may not be the problem, however there is a different very significant problem with technology. Specifically, technology providers and new products and services are way ahead of the consumer market for these offerings. In many cases it is the regulated utility business model, current pricing, and rate design policies that act as impediments to market development. Consumer electronics and appliance manufacturers claim that without some form of dynamic pricing consumers don't have any financial reasons to purchase smart appliances or automated controls. (see reference #2)

So the question becomes, what options do regulatory commissions need to consider to facilitate the market for smart grid consumer devices?

Regulatory Issues

1. Technology Framework
2. Security and Privacy
3. Standards
4. Interoperability
5. Future Proofing



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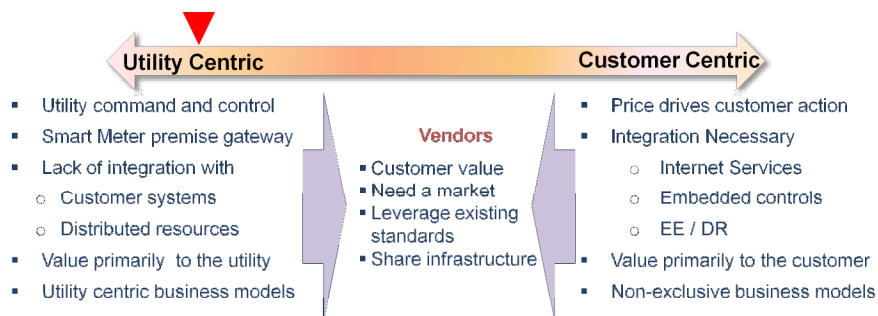
19

We've identified five of the most important issue relevant to customer automation technology, .

1. Technology Framework – How does customer automation technology fit into the existing regulatory structure of efficiency and demand response programs, financial incentives, and smart grid expectations? In addition, what options exist for encouraging innovation, cost reduction, and implementation?
2. Security and Privacy – Are customer automation technologies safe and how should regulators deal with security and privacy?
3. Standards – What role should standards play? How with the NIST standards development process impact customer automation technologies, and can commissions proceed now with implementation efforts before the standards are completed?
4. Interoperability – What is interoperability? Will customer automation technologies implemented today be made obsolete by future standards, and what role should regulatory commissions consider?
5. Future proofing – What is future proofing?

Technology Framework

Smart Grid use cases emphasize a utility rather than a customer perspective.



The features, availability, and cost of smart grid consumer automation technologies depend on the stakeholder's point of view.



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Use cases describe business process and operating scenarios that specifically address which parties participate, each of their roles and responsibilities, information exchanges, and timing and equipment issues. This graphic illustrates that the assumptions underlying the development of a use case can create very different outcomes. For smart grid, we've characterized the use cases along a continuum that at one extreme emphasizes a 'utility centric' position and at the other extreme a 'customer centric' position. While use cases at either extreme may favor one market participant over another, the outcomes establish the value.

The use cases introduced to support advanced metering business cases and especially those developed to support the NIST smart grid standards generally are considered 'utility centric'. The utility centric perspective is best illustrated by existing DR program options, where the utility provides the rules, incentives, technology, installation and operation – a complete turn-key approach. While this approach is necessary to support research pilots, it is not necessarily a good approach for supporting broad widespread market implementation. The utility centric approach uses a bid process that favors a few technology vendors, standardized features designed for the average customer, and operating practices that don't integrate very well with customer-owned health, security, entertainment, and energy management systems. This approach tends to favor value to the utility rather than value to the customer, which is currently evident in some of the advanced meter and smart grid protests. Customers don't see value from metering or smart grid and utility claimed cost reductions don't satisfy their need for value.

Smart appliance and consumer electronics suppliers are caught in the middle. They need a market to define their value function, who they market to, and what products and services they design for their market. The utility market is much smaller, values innovation less, and tends to favor large over small vendors. A customer based market will be much larger, more competitive, create opportunity for many more vendors, but also will be much more dependent upon pricing to establish the customer value function. In a utility centric market, utilities will generally specify their own standards, while in a customer centric market vendors will first attempt to leverage existing standards, like Internet protocol.

Utility - Customer Perspectives - 1

Frameworks that Influence Technology Development / Deployment

Technology Framework	Utility Centric	Customer Centric
Equipment / Service providers	<ul style="list-style-type: none"> • utility contracts with 1-2 vendors 	<ul style="list-style-type: none"> • Many vendors • Viable market
Automation Technology Features	<ul style="list-style-type: none"> • Utility functionality • Limited supply – higher cost • Limited integration with customer systems 	<ul style="list-style-type: none"> • Customized functionality • Open supply – lower cost • Integrated into existing systems / transparency
Customer Participation	Limited by usage level or appliance ownership	All customers
End-uses, load targeted	Primarily HVAC	All load
Purchase and Installation	Utility provided.	Incentives, rebates to accelerate
Customer Incentives	Participation or event based payments	Time varying price differentials
Integration of EE and DR	Not usually addressed	Integration necessary
Control strategies	<ul style="list-style-type: none"> • Utility selected • Emphasis on shedding 	<ul style="list-style-type: none"> • Customer selected • Shedding, shifting, optimization



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This slide highlights some of the features that distinguish the utility versus customer centric use case perspectives. Some of the key differences include:

• **Equipment / Service Providers** - This contrasts the competitive bidding process that most utility centric options follow with technology selection for any program option which typically results in the selection of 1-2 vendors based on bids against a standardized set of features. The customer centric approach generally opens up this acquisition process to more vendors and many products.

• **End-uses, load targeted** – Utility centric approaches, from a practical perspective, typically target only a few common residential customer loads – HVAC and water heating. While these loads have a high demand response and efficiency value, not all customers have qualified loads. The customer centric approach opens up the market to all customer loads. While control systems for some of the smaller loads may not be economically justified today, exposing them to a smart grid environment may encourage suppliers to build in embedded controls and additional operational modes (e.g. low power) to distinguish and add value to their products.

• **Control Strategies** – Because utility programs are designed for average customers, their control strategies tend to focus on a few limited shed options that are designed to better optimize the utility system. In contrast, when the customer manages the control strategy they may consider shedding, shifting, and other options to optimize their personal comfort, convenience, and value. The tradeoff for utilities and regulators is which approach is sustainable in the long-run?

While the utility centric and customer centric approaches are not mutually exclusive, they do have markedly different impacts on the features, costs, and market for smart grid appliances and control equipment as well as customer participation.

Utility - Customer Perspectives - 2

Key Challenges

- ❑ **Utility programs**
 - Typically don't support inexpensive or customized customer automation technologies.
 - Contracting process locks in preferred vendors
 - Development efforts often reinvent technologies and products that already exist.
- ❑ **Customers**
 - Want clear, reasonable incentives to invest.
 - Don't want single-purpose energy related products.
 - Need sustainable long-term education and implementation models.



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Examining the differences between the utility and customer centric approaches highlights basic tradeoffs that each supports. Utility centric programs typically don't support customized or inexpensive automation technologies, large numbers of competitive vendors, large markets, and they may in fact not support a smart appliance market.

If your commission believes that more open competitive markets for automation options is important to smart grid then regulatory policy needs to begin considering options that give customers more clear cut incentives, rebates, or subsidies to attract investors that encourage customers to acquire their own technology options. Rates and pricing, expanded incentives to encourage customer purchases of preferred technology options or to off-set implementation expenses (e.g. installation of a PCT), and new approaches to long-term educations might be appropriate.

Utility - Customer Perspectives - 3

Key Challenges

❑ Vendors

- Get mixed signals – who is the customer?
- Need a value function to support market development.*

Essential Requirements*

1. **Pricing** must provide incentives to manage energy use more efficiently and enable consumers to save money.
2. **Communication Standards** must be open, flexible, secure, and limited in number.
3. **Consumer Choice & Privacy** must be respected; the consumer is the decision maker.



* Smart Grid White Paper, The Home Appliance Industry's Principles & Requirements for Achieving a Widely Accepted Smart Grid, AHAM, December 2009, <http://www.aham.org/ht/a/GetDocumentAction/i/44191>

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The key challenges for vendors is a little different. Who is their customer, the utility or end consumer? What market are they supposed to address? In either case they need a value function to support market development.

The white goods vendors have submitted position papers and testified before FERC that customers need dynamic pricing to create incentives that encourage them to manage energy use and justify investment in smart appliances. They also want open, secure communication standards that don't require them to customize appliances and controls for each utility market. Finally, they don't believe that utility control is a viable approach since it runs the risk of compromising and adversely impacting the operation and services for a number of customer appliances. Instead, customers need to be the decision maker.

Utility - Customer Perspectives - 4

Potential Solutions

- ☐ Establish a clear demarcation point (logical fire wall) between the utility and customer (the meter).
- ☐ Consider alternatives to exclusive bundled utility programs for delivering customer smart grid automation technology, services, and education.
- ☐ Consider collaborative market models, where:
 - Utilities provide price, reliability, and event signals.
 - Utilities may provide rebates, screening and referral resources to encourage the market.
 - Customers acquire, own, and operate automation technologies
- ☐ Examine rates that provide price signals and incentives to support customer investment and behavior change.



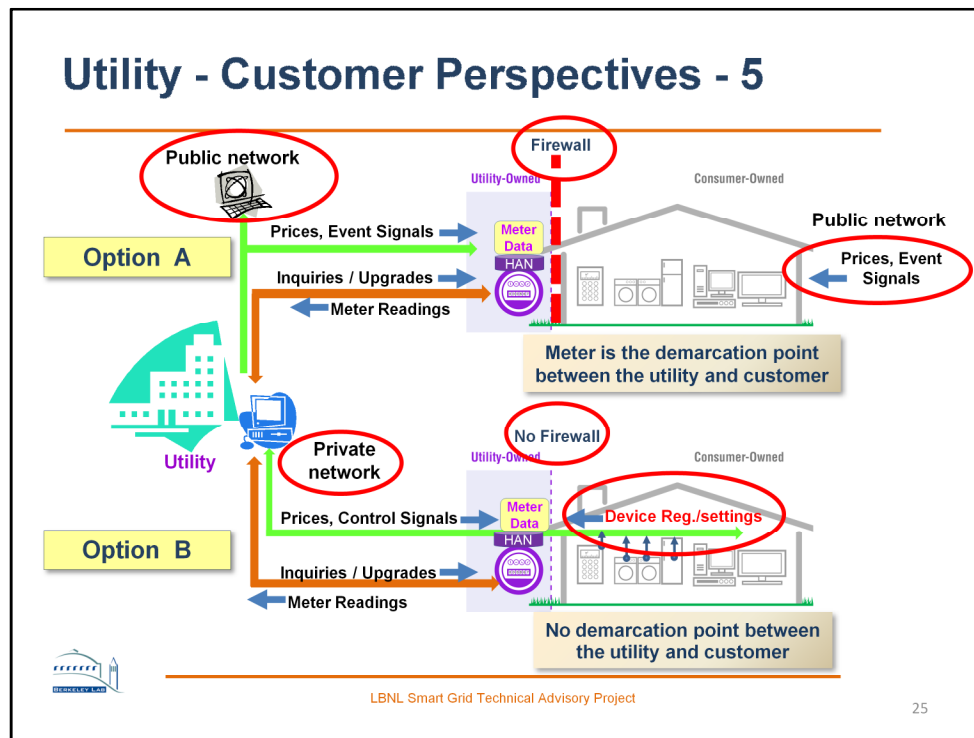
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In order to minimize costs and inconvenience for consumers relative to policy decisions that impact “customer automation technologies”, there are potential solutions for regulators, however most of the options we’ve highlighted require material changes in conventional demand response program structures, rate designs, and how the utility interfaces with the customer.

For example:

- ☐ Establish a clear demarcation point (logical fire wall) between the utility and customer (the meter). Clearly differentiating utility and customer responsibilities allows the consumer market to grow and innovate and has positive impacts on privacy and security.
- ☐ Consider alternatives to exclusive bundled utility programs for delivering customer smart grid automation technology, services, and education. Consider collaborative market models, where:
 - Utilities provide price, reliability, and event signals.
 - Utilities may provide rebates, screening and referral resources to encourage the market.
 - Customers acquire, own, and operate automation technologies.
- ☐ Examine rates that provide price signals and incentives to support customer investment and behavior change.



This slide provides a schematic framework with two bounding scenarios (Options A & B).

The schematic has been created to differentiate the utility- vs. customer-centric approaches by defining a logical firewall between the utility and a customer-owned facility such as a home. The location of the logical firewall will impact the complexity of the four “customer automation technology” topics I promised to discuss, i.e., (1) security and privacy, (2) standards, (3) interoperability, and (4) future proofing. Option A has a logical firewall defined within the utility meter. In this scenario, the Advanced Metering Infrastructure (AMI) utility-network transceiver (the physical element that connects the meter to the communications channels back to the utility) would be located in the utility domain whereas the home area network (HAN) transceiver (the physical element that connects the meter to the communications channels in the home) would be in the customer domain. Option B allows direct utility access to customer-owned devices (e.g., appliances), and, therefore, has no single logical firewall. In this scenario, logical firewalls may have to reside in all the devices that they intend to access.

Option A is the customer-centric approach and makes the customer responsible for their own loads. Option B is the utility-centric approach and makes the utility liable for all the loads they directly control. Over the next few slides, I will discuss the policy implications of these two bounding scenarios on (1) security and privacy, (2) standards, (3) interoperability, and (4) future proofing.

Security and Privacy - 1

Definition of Privacy*

Under GAAP**, privacy is defined as “the rights and obligations of individuals and organizations with respect to the collection, use, retention, and disclosure of personal information.”

Key Areas

1. Collection
2. Use
3. Retention
4. Disclosure

* NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0 (Draft), http://www.nist.gov/public_affairs/releases/smartgrid_interoperability.pdf

** Generally Accepted Accounting Principles



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Security and privacy have become a huge hurdle for advancing customer automation technologies. The utility-centric approach, which is the principle option being considered in most smart grid discussions, eliminates the logical firewall between the utility and customer that the meter previously provided. Now smart meters extend the operational domain of the utility beyond the meter into the customer facility, where the objectives include the collection of information to specifically identify customer appliances, settings, and operating practices. Eliminating the demarcation between the utility and customer domain and collecting detailed customer end-use information raises many privacy concerns. If the operational domain of the utility were to stop at the meter, security and privacy issues would be far less complex.

Privacy is defined with respect to the collection, use, retention and disclosure of personal information. Practices that limit the collection of personal information immediately impact privacy concerns.

Security and Privacy - 2

Can security and privacy be addressed?

- ❑ Establish a clear demarcation point (logical fire wall) between the utility and customer (the meter).
 - Customers responsible for ensuring privacy for data collected within their premise.
 - Utilities responsible for maintaining privacy of all collected revenue meter data.
 - Physical firewall implementations will vary
- ❑ Existing broadband networks already address privacy and provide utilities with critical infrastructure communication services.



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Security and Privacy policy questions essentially involve the location of a line of responsibility and liability between utility and customer.

Can security and privacy be addressed? The key is to consider who might be responsible for what energy-related data.

A clear demarcation between utility and customer responsibilities further differentiates what data is collected and who is responsible, which can translate into very different approaches for addressing privacy issues.

While utilities must collect energy usage information to support operational and billing requirements, regulators need to examine whether it is necessary to go beyond the meter and collect end-use data, whether there are options to the collection of this information, and the various cost and liability tradeoffs between options.

While private utility communication networks have clear benefits, developing the security and privacy capabilities necessary to protect these networks often requires reinvention of measures already supporting existing broadband networks. A key question that needs to be asked is why existing broadband networks can't be used to support a designated part of the smart grid functionality.

Standards - 1

Can implementation of customer automation technologies proceed before the NIST standards have been completed?

- ☒ Yes
☒ Maybe
☒ No

- ☐ The NIST process provides guidance for the development of standards.
- ☐ It is possible the NIST process will not result in a set of mandated, enforceable standards.
- ☐ It is likely that standards will be adopted by the 'market' based on product performance, value, and customer acceptance

An Alternative Question

Can you implement now and provide: (1) interoperability and (2) future proofing?

- ☐ Leverage existing standards and existing infrastructure.



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Can implementation of customer automation technologies proceed before the NIST standards have been completed? Different stakeholders will answer this question differently because of their perspective.

- ☐ The NIST process provides guidance for the development of standards.
- ☐ It is possible the NIST process will not result in a set of mandated, enforceable standards.
- ☐ It is likely that standards will be adopted by the 'market' based on product performance, value, and customer acceptance

A more important question might be "can we implement something now?"

The answer is clearly yes. However implementation will require that utilities and vendors leverage existing standards and existing infrastructure. For example, the privacy and interoperability standards developed to support banking, investment, and shopping applications are already provided with Internet applications that have proven track records and widespread industry support. These same standards can be adapted to utility smart grid applications.

Standards - 2

- ☐ De facto vs. de jure
- ☐ Hardware vs. software interoperability
- ☐ Networks (LAN, HAN, FAN, WAN, ...)
- ☐ Protocols (communications, 7-layer model)
 - Zigbee vs. WiFi, HomePlug, Z-wave vs. ...
- ☐ Data Models
 - OpenADR vs.
 - SEP 1.0, 1.x, 2.0 (in facility vs. to facility)
- ☐ Utility back office vs. cloud computing



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The development of standards involves complex multi-year (sometimes multi-decade) processes. In addition, standards typically evolve *post facto*, after the fact or after some period of implementation (called de facto standards). Legal or de jure standards are rarely developed pre-market or prior to an extended period of implementation and debugging. De jure or formal legal standards typically evolve from de facto standards that have been formalized by an official Standards Development Organization (SDO) process. De facto standards often evolve from proprietary methods of doing something that are made public by the vendor that developed them.

The hardware standards development process is very different from the software standards development process. It's not as easy to *evolve* a hardware standard (e.g., a serial computer port) once the hardware is in place. Only the firmware embedded can usually evolve, i.e., be up-graded. For example, a USB 2 serial port is physically backward-compatible to allow devices that originally connected via the slower USB 1 port. The product with a USB 1 port is not stranded but it can't use the full capability of USB 2 unless it gets a firmware upgrade. If the form factor of the physical connector (i.e., the hardware) changes, older devices may become stranded and incompatible with the new form factor.

Software standards, on the other hand, can evolve more easily as long as previous versions are subsets of newer versions, e.g., Wi-Fi. IEEE 802.11 a/b is supported by 802.11 g which is supported under 802.11 n. The emerging ZigBee and SEP standards have NOT maintained backward compatibility so far. However, recently, there has been pressure to ensure that at least SEP 2 software will include backward compatibility with SEP 1 even though the proposed ZigBee network and transport layers are not backward compatible with older ZigBee communications stacks.

Standards – 2 (continued)

- ☐ De facto vs. de jure
- ☐ Hardware vs. software interoperability
- ☐ Networks (LAN, HAN, FAN, WAN, ...)
- ☐ Protocols (communications, 7-layer model)
 - Zigbee vs. WiFi, HomePlug, Z-wave vs. ...
- ☐ Data Models
 - OpenADR vs.
 - SEP 1.0, 1.x, 2.0 (in facility vs. to facility)
- ☐ Utility back office vs. cloud computing



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Communications network standards also depend on the characteristics of the networks that are being considered.

Communications protocol standards depend on an understanding of the 7-layer OSI Communications Reference Model that was developed in the late 1970's in anticipation of telecommunications industry deregulation.

Layer 7 of the OSI model involves applications which require standard data models.

Finally, standards for utility back-office computing are different from Internet cloud computing even though they may share common goals and functions. And the utility Inter-Control Center Communications Protocol (ICCP) is different from the Internet's Transport Control Protocol / Internet Protocol (TCP/IP).

Concepts such as interoperability and future proofing are facilitated but not guaranteed by standards.

Smart Grid customer automation technology standards are far more complex than single-widget standards. Customer automation technologies are typically termed "systems of systems" and can interact with multiple networks. I expect that customer automation devices will be similar to smart phones insofar as their standards are concerned. Smart phones move seamlessly between networks, employ a variety of communications protocols and interface different physical media channels. These secure standards exist and can be adapted to other devices.

The purpose of communications protocols is to convey understandable information. This requires standards, e.g., Internet Protocol. It also requires language standards, e.g., XML; security standards, e.g., HTTPS; and data model standards. SEP and OpenADR are emerging data model standards that don't compete but do overlap somewhat. Policymakers need to understand what they do, where they fit in the scheme of things and the policy implications.

Finally, customer automation technology will be affected by utility web sites powered by a back office application as well as third-party web sites. Privacy and security standards can leverage Internet standards.

To make the standards process less complex, policymakers could insist on using existing standards, e.g., the IETF & IEEE, and leveraging existing infrastructure, e.g., the Internet. However, using existing standards and leveraging existing infrastructures, policymakers will need to understand paradigms such as the 7-layer OSI Communications Reference Model, vertical vs. horizontal architectures, the need for reference designs, and other technology frameworks.

Standards - 3

Comments from the FERC Proceeding

- ❑ "... prescribing solutions through regulations runs the risk of stifling innovation, tying the pace of new Smart Grid developments to the speed of the regulatory process." (AT&T)*
- ❑ "This process is best driven through industry-led standards efforts and conformance/certification programs, free market dynamics, and the cooperation between utilities, industry and other smart grid stakeholders." (Intel)**
- ❑ "The Commission has clearly stated on a number of occasions that it does not believe EISA gives it the authority to mandate or enforce smart grid standards I infer that the Commission's goal is to provide forward looking guidance to insure realization of smart grid functionality and interoperability as envisioned by EISA." (NIST)***

* FERC Docket No. RM11-2-000, Supplemental Notice Requesting Comments, Smart Grid Interoperability Standards, Comments of AT&T, March 8, 2011.

** Ibid, Intel, March 17, 2011.

*** Opening Remarks by George W. Arnold, National Coordinator for Smart Grid Interoperability, National Institute of Standards and Technology, FERC Technical Conference on Smart Grid Interoperability Standards, January 31, 2011.



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One of the concerns at the outset of the NIST standards process was the possibility that FERC or other Federal agencies might mandate requirements that reach into state jurisdictional and regulatory domains.

In December 2010 NIST passed five standards considered the most mature, well defined and accepted within the utility industry to FERC for consideration. While the industry applauded the NIST process, the comments on this slide illustrate the consensus cautious view to avoid mandating standards at this time reflected in comments from 34 organizations representing utilities, vendors, trade organizations, and regulatory commissions.* Comments from many of the organizations expressed concern that the standards were premature, the full consequences were not yet fully understood, and that mandates would have cost and enforcement implications that have not yet been documented and are not yet well understood.

* Summaries of Comments Submitted in Response to FERC's Notice Requesting Comments re: Smart Grid Interoperability Standards, EEI RM11-2, April 12, 2011.

Interoperability and Future Proofing - 1

- ❑ What is interoperability? (hardware vs. software)
- ❑ What are the key strengths / weaknesses?
 - existing utility vs. customer centric models
 - ZigBee SEP 1.0, SEP 2.0 vs. the Internet
- ❑ What are the options to address interoperability?
 - Reprogrammable logic, layered architecture
 - USNAP, integrated gateways



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As I have already mentioned, hardware and software standards are different. Interoperability can be facilitated by standards but standards don't guarantee interoperability. Also interoperability is not the same as interchangeability. The 110-volt wall socket is a US standard that facilitates the use of appliances from different manufacturers. It facilitates "interchangeability" NOT interoperability. Interoperability is related to exchanging and sharing information between devices to facilitate system operation. Hardware interoperability involves communications channels (layer 1, media) standards like 802.15.4, 802.11, 803, etc. Software interoperability involves protocol standards (layer 2, media access control firmware, layer 3, network software, layer 4 transport software, and layer 5-7 application software). These elements are part of the 7-layer OSI Communications Reference Model that I have already mentioned. SEP and OpenADR are applications packages (part of the 7th layer) that act on information. Policymakers will need to become more familiar with where terms such as ZigBee, Wi-Fi, TCP/IP, XML, HTTPS, etc., fit into the 7-layer model. Lack of this knowledge has already led to activities that in my opinion may not be required.

Interoperability and Future Proofing - 2

- ☐ What is future proofing?
- ☐ What are the key strengths / weaknesses of existing utility vs. customer centric models?
- ☐ What are the options?
 - Hardware: USNAP vs. USB
 - Software: horizontal vs. vertical interfaces
- ☐ Drawing boundaries and control volumes



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What is future proofing? Future proofing maintains the viability of products to operate and be interoperable as hardware and software technologies change. Hardware and software technologies are always changing but a consumer should be able to use a product at least until the product has had a reasonable return on its investment.

What are the key strengths / weaknesses of existing utility vs. customer centric models?

a. Utility Centric Model:

- 1) Strength: best suited for systems without customer automation, limited to single purpose demand response day-ahead system objectives.
- 2) Weakness: discouraging third-party developers and service providers by establishing a “gate keeper” environment that channels all communication through the meter while attempting to control individual customer loads.

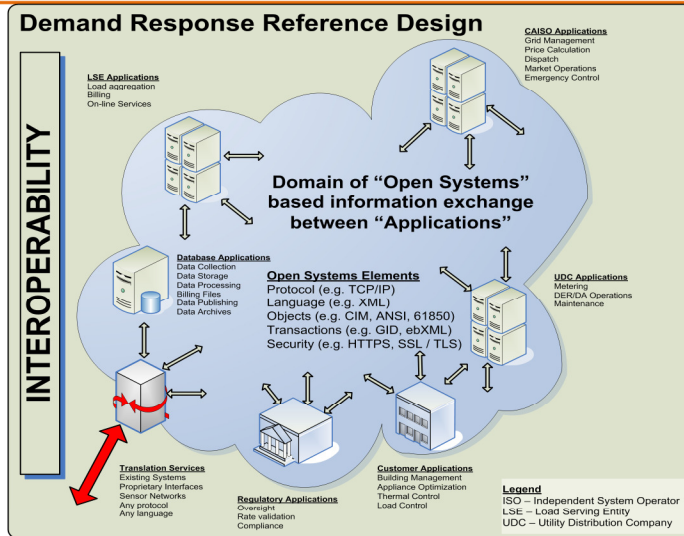
b. Customer Centric Model:

- 1) Strength: develop standardized price, reliability, and event signal under dynamic rates that encourage customers to own and manage their own automated controls and smart appliances.
- 2) Weakness: the utility does not control customer response nor the overall infrastructure development process.

What are the Options? Equipment vendors are already developing approaches to provide customer automation with future proofing and interoperability capability. Options will evolve, like USNAP*, however the development process will take time and it will require regulatory actions to encourage dynamic pricing that will open the market and provide customers with a clear value function.

* <http://www.usnap.org/Default.aspx>

Interoperability and Future Proofing - 3



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Slide 33 was presented at CEC workshop in 2005 and represents a utility reference design for demand response system interoperability. Note the “Open Systems Elements” listed in the middle that separately are required to ensure interoperability. Interoperability requires knowledge of many domains of expertise. Also notice that the customer is for the most part outside the utility cloud.

Interoperability and Future Proofing - 4

Are there options to address interoperability and future proofing?

- ❑ Software :
 - Remote upgrades
 - Layering
- ❑ Hardware
 - Module flexibility (USNAP)
 - Gateways and mapping



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Are there options to address interoperability and future proofing?

The evolution of the personal computer and development of today's Internet architecture provides a model for addressing smart grid interoperability and future proofing. While the details can become very technical, there are at least three key elements that are needed to be addressed relative to smart grid.

1. Open, Non-proprietary data models – Data models in their most simple form are just pre-defined formats or structures for defining prices or rates, event signals, or messages. For example, if all utilities could agree on a standard “format” or data model to describe the prices in a Time-of-Use rate, then manufacturers, vendors, and service providers could develop displays, automated controls, and systems that could interpret these signals and work anywhere. System “A” for displaying the price in hour 23 would work in utility “1”, “2”, or “3”. This creates interoperability.
2. Remote upgrades – Smart grid is in the early stages of development, which guarantees that customer automation hardware and firmware (the software that runs the hardware) will almost certainly change as system requirements mature. Site visits to update the firmware in a meter, a programmable communicating thermostat, or other control device are expensive and intrusive. Therefore it is critical that most of these devices have capability to be remotely upgraded. Automatic upgrades to personal computer security programs and operating systems provide examples that have evolved to update both the functionality of a program and to address changing security and other issues.
3. Gateways and Expansion Ports to Address Uncertainty – The programmable communicating thermostat (PCT) with USNAP modules depicted in this slide illustrates one way to address uncertainty. In this case, there is no standard that defines a single best way to communicate with PCT's, so the vendor has designed expansion ports that can accommodate any variety of common communication options. This approach creates a form of gateway that can be reconfigured as needs or systems change. Early versions of personal computers took this same approach by including expansion ports to accommodate a variety of serial and parallel connections for linking printers, modems, and a variety of other devices. As the industry matured, external expansion ports were replaced with lower cost USB connectors and firmware. Future PCT's, smart appliances, and other smart grid devices will almost certainly follow the same path. As systems mature, standards will evolve that eliminate the need for external expansion ports.

4. Summary

- ❑ **Utility vs. consumer-centric views can be harmonized with proper metrics that focus on long-term rather than short-term**
 - Cost and innovation opportunities
 - Infrastructure versus separate, add-on devices
 - Expanded industry participation in customer education
- ❑ **Regulatory decisions.**
 - Technology and products exist
 - Interoperability models exist
 - De facto standards exist
 - Security and privacy can be addressed
- ❑ **Markets for customer automation products and services need time-varying pricing to establish a value function**



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V. References

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	Title	Link
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2	Smart Grid White Paper, The Home Appliance Industry's Principles & Requirements for Achieving a Widely Accepted Smart Grid, AHAM, December 2009	http://www.aham.org/ht/a/GetDocumentAction/i/44191
3	Energy Management, A Mass Market Consumer Opportunity	http://ase.org/sites/default/files/BBY%20Energy%20Management%20White%20Paper.pdf
4	Get Smart, IEEE Power & Energy Magazine, May/June 2010	http://www.ieee.org/organizations/pes/public/2010/may/current.html Note: Available to IEEE members.
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Vendor Technology Information / Videos*

	Title	Link
1	Our Home Spaces	<input type="checkbox"/> http://dl.dropbox.com/u/2117050/OHS%20QADR%20Solution.mp4 <input type="checkbox"/> http://dl.dropbox.com/u/2117050/OHS%20QADR%20Products.mp4
2	Enmetric	http://www.enmetric.com/docs/enmetric-brochure.pdf
3	People Power	http://www.peoplepowerco.com/
4	Tendril	http://tendrillinc.com/products/
5	Radio Thermostat of America	<input type="checkbox"/> http://www.radiothermostat.com/ , http://www.radiothermostat.com/filtrete/ <input type="checkbox"/> http://www.radiothermostat.com/filtrete/
6	GE Appliances	http://www.geappliances.com/home-energy-manager/
7	Honeywell	https://buildingsolutions.honeywell.com/Cultures/en-US/Markets/Utilities/
8	Ecobee	http://www.ecobee.com/product/smart-thermostat-features/
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* This information is presented for information purposes only. None of the references on this slide are intended to advocate or endorse any technology or vendor.



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Vendor Technology Companies*

Vendor	Product	Vendor	Product
2 Save Energy	Owl	Green Energy Options	Duet
4Home	OCM only	Gridpoint	Home Energy Management
Aclara	TWACS IHD	Home Automation Europe	Power Player
Agilewaves	The Resource Monitor	Honeywell	UtilityPRO™
AlertMe	AlertMe Energy	iControl	Connected Life
Ambient	Energy Joule, The Energy Orb	In2Networks	
Ampy Email Metering	EcoMeter	Jettun	JIM
AsTech	In-Home Display	LS Research	RateSaver
BlueLine Innovations	PowerCost Monitor	Lucid Design Group	Building Dashboard
Converse	Power Portal, SuperStat®	Microsoft	Holm
Control4	EC-100	Onzo	Smart Energy kit
Current Cost Ltd	CC128	OpenPeak	Tablet 7
DIY KYOTO	Wattoon, Holmes	P3 International	Kill-a-watt
Eco-eye	Eco-eye Elite	Pluwise	
EcoDox	FIDO	Power House Dynamics	eMonitor
Efergy	eLife	PowerMand	DreamWatts
eMeter	Energy Engage	PRI	Home Energy Controller
Energygate	Inspiration Thermostat	Residential Control Systems	(modular)
Energy Aware	PowerTab	San Vision Energy Technology	Mobile Energy Assistant
Energy Inc	The Energy Detective	Seasonic	Power Angel
Energy Monitoring Technologies	The Meter Reader EM-2500	Shasaa	Smart Home Kit
EnergyHub	EnergyHub	Silver Spring Networks	CustomerIQ
Enmetric Systems		Tendril	Vantage, Insight, Set Point
General Electric	Energy Monitoring Dashboard	Tenright	PicoWatt
Google	PowerMeter	Trilliant	Energy Valet
		USCL	EMS-2020
		WeatherWise	EnerCheck
		Wireless Monitors Australia Pty Ltd	Centameter



* Information provided from the SMUD-Demand Response Research Center, Residential Information and Controls Pilot.

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References - 4

Webinar Question

- **What about the digital divide, where customers don't have access to the Internet much less iPhones?** While Internet is a potential communication channel to the home, there are many other publicly available options that can provide the price and event signals necessary to support smart appliances and controls. For example broadcast TV, cable TV, cellular, FM radio, RDS FM subcarriers like that used to supply text on car radios, powerline, etc.

